

1 SPECIFICATION

2
3 ULTRASOUND ENDOSCOPE

4
5 BACKGROUND OF THE INVENTION

6 Field of the Art

7 This invention relates to an ultrasound endoscope which is
8 capable of both endoscopic and ultrasound examinations in body
9 cavities, and more particularly to an ultrasound endoscope which is
10 arranged to facilitate maintenance and service such as inspection,
11 repair and replacements of internal component parts within a rigid
12 tip end section at the distal end of an insertion instrument of an
13 ultrasound endoscope.

14 Prior Art

15 Generally, ultrasound endoscopes are provided with an
16 endoscopic observation means including an illumination window and
17 an observation window on a rigid tip end portion at a distal end of an
18 elongated insertion instrument along with an ultrasound
19 examination means such as an ultrasound transducer. After

1 introducing the insertion instrument into a body cavity, an
2 intracavitary site of interest is firstly examined by the endoscopic
3 observation means, and then the ultrasound examination means is
4 used to further examine tissues in a diseased portion or a suspicious
5 portion which has been spotted as a result of the endoscopic
6 examination. In many cases, the so-called biopsy channel is provided
7 in and through the endoscopic insertion instrument for forceps or a
8 high frequency surgical or biopsy instrument to be introduced into a
9 body cavity and operated under observation through the endoscopic
10 observation means or for a puncture needle or other puncture
11 instrument to be operated under observation through ultrasound
12 scan images.

13 Connected to the base end of the insertion instrument of the
14 ultrasound endoscope is a manipulating head assembly to be gripped
15 by an operator at the time of endoscopic or ultrasound examination.
16 Various operation control buttons and levers are provided on the
17 manipulating head assembly. The insertion instrument has an
18 elongated flexible body which can be bent easily along the shape of a
19 path of insertion, and an angle section and a rigid tip end section are

1 successively connected to the fore end of the elongated flexible body.

2 The above-mentioned endoscopic observation means, ultrasound
3 examination means and biopsy channel are provided on the rigid tip
4 end section. Accordingly, by operating the manipulating head
5 assembly to turn the angle section in an upward, downward,
6 rightward or leftward direction, the rigid tip end section can be
7 turned into an arbitrary direction.

8 As described above, the endoscopic observation means,
9 ultrasound examination means and biopsy channel are mounted on
10 the rigid tip end section which constitutes a distal end portion of the
11 endoscopic insertion instrument. The ultrasound transducer which
12 constitutes an ultrasound scan means is classified into either a
13 mechanical scan type or an electronic scan type depending upon
14 scan mode. In the case of an electronic scan type, the ultrasound
15 transducer is constituted by a large number of transducer elements
16 which are arrayed in a predetermined direction. At the time of an
17 electronic scan, the transducer elements are driven successively one
18 after another or transducer elements in a number of transducer
19 element groups are successively driven to obtain echo signals.

1 On the other hand, the endoscopic observation means is largely
2 composed of an illumination window in which a light emitting end of
3 an illumination light guide is located, and an observation window in
4 which a lens tube of an optical objective lens system is mounted. A
5 solid-state image sensor device (or a light incident end of an image
6 light guide) is located at the focus of the optical objective lens system.
7 The optical objective lens system and the solid-state image sensor
8 device are assembled together and provided as an image pickup
9 assembly unit. Further, a biopsy channel, i.e., a passage for biopsy
10 and surgical instruments, is generally constituted by a flexible tube
11 which is bendable within the flexible body portion and angle section
12 of the insertion instrument. A passage way leading to an outlet
13 opening of the biopsy channel is bored through the rigid tip end
14 section at the distal end of the insertion instrument. A connector
15 pipe is fitted in the outlet passage way and a fore end portion of the
16 flexible biopsy channel tube is connected to a base end of the
17 connector pipe which is projected by a predetermined length from
18 the proximal end of the rigid tip end section.

19 In laying out the various component parts of the endoscopic

1 and ultrasound examination means on the rigid tip end section at the
2 fore distal end of the insertion instrument, it has been known in the
3 art to locate the ultrasound transducer at the distal end of the rigid
4 tip end section, with ultrasound transducer elements arrayed in a
5 convexly curved shape in the axial direction of the rigid tip end
6 section. The observation window of the endoscopic observation
7 means is provided in a sloped surface rising gradually upward toward
8 the rear end of the rigid tip end section from the proximal end of the
9 ultrasound transducer mount portion. Illumination windows are
10 provided on the opposite lateral sides of the observation window. The
11 biopsy channel is opened at a position between the ultrasound
12 transducer mount portion and the observation window of the
13 endoscopic observation means. Ultrasound endoscopes having the
14 component parts of the endoscopic and ultrasound examination
15 means laid out in this manner are known in the art, for example.,
16 from Japanese Laid-Open Patent Application 2002-238906.

17 In connecting a rigid tip end section to an angle section of an
18 endoscopic insertion instrument, it is usually the case to connect the
19 rigid tip end section separably to the angle section which is

1 constituted by a series of flexibly connected rings. For this purpose,
2 a foremost ring of the angle section is fitted and fixed on a proximal
3 end portion of the rigid tip end section. An outer skin layer of the
4 angle section is extended to a position beyond and forward of the
5 foremost ring, and securely fixed on the rigid tip end section by line
6 wrapping and an adhesive agent. The reason why the rigid tip end
7 section is separably connected to the angle section is to make the
8 maintenance and service of the component parts of the endoscopic
9 and ultrasound examination means feasible, that is to say, to permit
10 inspection, repair and replacements of internal component parts of
11 the rigid tip end section.

12 In this regard, as already mentioned hereinbefore, an
13 ultrasound transducer is mounted on the rigid tip end section. Wires
14 from the respective ultrasound transducer elements on an ultrasound
15 transducer assembly are led out from the transducer assembly and
16 passed through the angle section and the elongated flexible main
17 body portion of the insertion instrument and connected to
18 corresponding wiring members in the manipulating head assembly of
19 the endoscope. Further, signal lines of the endoscopic observation

1 means, that is to say, signal lines which are connected from the solid-
2 state image sensor device and led out from the image pickup
3 assembly unit are also passed and extended through the angle
4 section and the flexible body portion of the insertion instrument
5 along with a bundle of fiber optics of the light guide which transmits
6 illumination light to the illumination windows. Furthermore, a tube
7 which serves as a biopsy channel is also passed through the angle
8 section and the flexible main body and extended as far as the
9 manipulating head assembly of the endoscope.

10 Generally, in the case of an ultrasound endoscope with an
11 electronic scan type ultrasound transducer, it is the ultrasound
12 transducer which is most expensive among the various component
13 part which make up the ultrasound endoscope. Nevertheless, it has
14 been extremely difficult to repair the ultrasound transducer when it
15 is damaged or in the event of malfunctioning. That is to say, it has
16 been virtually impossible to carry out maintenance and service on the
17 ultrasound transducer. In contrast, it is relatively easy to replace the
18 solid-state image sensor device and its wiring, the light guide and the
19 biopsy channel tube when damaged.

1 Therefore, when the rigid tip end section is detached from the
2 angle section, the jobs of maintenance and service have been limited
3 to the solid-state image sensor device and its wiring, the light guide
4 and the biopsy channel tube. Above all, internal surfaces of the
5 biopsy channel tube are susceptible to damages since the biopsy
6 channel is often used for insertion of puncture instruments with a
7 sharp-pointed puncture needle. Further, breakage could occur to the
8 signal lines from the solid-state image sensor device.

9 In order to enhance the resolution of ultrasound images, it is
10 necessary for an ultrasound endoscope with an electronic scan type
11 ultrasound transducer to increase the number of ultrasound
12 transducer elements and to use a wiring system involving a
13 considerably increased number of wiring connections. Therefore,
14 when the rigid tip end section is detached and pulled away from the
15 angle section to repair or replace a certain component part,
16 difficulties are often encountered in separating the repairing or
17 replacing component part from other component parts which are
18 densely packed in the rigid tip end section of the insertion
19 instrument. Therefore, it has been extremely difficult and

1 troublesome to inspect, repair or replace a particular component part
2 separately from other densely packed component parts, without
3 damaging other component parts. Especially, in case the ultrasound
4 transducer and the wiring to the transducer are made detachable or
5 separable from the rigid tip end section to facilitate maintenance and
6 service jobs on component parts other than the ultrasound
7 transducer and its wiring, the construction of the rigid tip end section
8 will become too complicate and will become a great obstacle to the
9 maintenance and service.

10 Besides, at the time of relocating an image pickup assembly
11 unit on the rigid tip end section of the insertion instrument, it is
12 necessary to adjust its position in the rotational or radial direction.
13 Further, regarding the biopsy channel, the biopsy channel tube is
14 extended axially through the insertion instrument to a point
15 immediately on the proximal side of the rigid tip end section and
16 connected to a bent connector pipe which is fitted in a forwardly
17 upturned exit passage in the rigid tip end section. Accordingly, the
18 connector pipe has particular directionability in bending direction. It
19 follows that the lens tube of the optical objective lens system as well

1 as the connector pipe has to be securely and firmly fixed in position
2 by application of an adhesive after adjusting its position relative to
3 the rigid tip end section. Therefore, the applied adhesive has to be
4 stripped off to take out the optical image pickup assembly unit and
5 the biopsy channel from the rigid tip end section for maintenance
6 and service. On such an occasion, there are increased possibilities of
7 damaging other component parts which happen to be in the close
8 proximity.

9 SUMMARY OF THE INVENTION

10 In view of the foregoing situations, it is an object of the present
11 invention to provide an ultrasound endoscope having a rigid tip end
12 section at the distal end of an insertion instrument housed in a
13 casing which can be split into a main casing and a separable head
14 block to facilitate maintenance and service of internal component
15 parts of the rigid tip end section.

16 It is another object of the present invention to provide an
17 ultrasound endoscope having a rigid tip end section at the distal end
18 of an insertion instrument to accommodate an ultrasound scanner
19 means along with an endoscopic observation means, the rigid tip end

1 section being housed in a casing which can be split into a main
2 casing adapted to accommodate component parts of the ultrasound
3 scanner means fixedly therein and a separable head block adapted to
4 accommodate at least part of component parts of the ultrasound
5 observation means releasably to permit repair or replacements of the
6 component parts of the endoscopic observation means separately of
7 and without causing damages to component parts of the ultrasound
8 scanner means.

9 According to the present invention, in order to achieve the
10 above-stated objectives, there is provided an ultrasound endoscope
11 having a rigid tip end section connected to a fore end of an angle
12 section at the distal end of an insertion instrument for
13 accommodating an ultrasound transducer along with endoscopic
14 observation means including an illumination means and an optical
15 image pickup assembly unit; the ultrasound transducer being
16 accommodated in a front portion of a generally tubular casing of the
17 rigid tip end section, the endoscopic observation means being fitted
18 in a sloped wall section provided on the casing on the rear side of the
19 ultrasound transducer and inclined obliquely upward in the rearward

1 direction, and an outlet opening of a biopsy channel outlet passage
2 opened in the casing at a position between the endoscopic
3 observation means and the ultrasound transducer: characterized in
4 that: the casing of the rigid tip end section is separable into a main
5 casing adapted to accommodate entire parts of the ultrasound
6 transducer and a separable head block adapted to accommodate at
7 least part of component parts of the endoscopic observation means
8 and separably joined with the main casing; joining wall portions are
9 provided along longitudinal split lines at opposite lateral sides of the
10 main casing and the separable head block as well as along a
11 transverse split line on the rear side of the ultrasound transducer; a
12 foremost ring member of angle rings in the angle section is removably
13 fitted on a circular ring fitting surface provided around joined base
14 end portions of the main casing and the separable head block; and a
15 fore end of an outer skin layer of the angle section is extended
16 forward beyond the ring fitting surface and fixedly anchored on a
17 circular outer skin layer anchor surface provided around joined base
18 end portions of the main casing and the separable head block on the
19 front side of the ring fitting surface.

1 According to the present invention, the rigid tip end section of
2 the insertion instrument is housed in a casing which can be split into
3 a main casing and a separable head block. The main casing is
4 adapted to accommodate an ultrasound transducer assembly fixedly
5 therein, while the separable head block is adapted to accommodate at
6 least part of component parts of an optical image pickup system of
7 the endoscopic observation means. In this instance, the separable
8 head block of the rigid tip end section is adapted either to
9 accommodate all of an optical image pickup assembly unit including
10 an optical objective lens system and a solid-state image sensor device
11 along with a light guide and an illumination window fitted with a
12 diffuser lens in front of a light emitting end of the light guide or to
13 accommodate only part of these component parts. Alternatively, the
14 optical image pickup unit assembly, light guide and diffuser lens are
15 partly provided on the main casing and partly provided on the
16 separable block in such a way that they are assembled together and
17 fixed in position within the casing when the main casing and the
18 separable block are joined together.

19 Any way, the separable block is adapted to be joined with the

1 main casing through joining wall portions which are provided along
2 longitudinal split lines at its opposite lateral sides as well as along a
3 transverse split line provided at a position on the rear side of the
4 ultrasound transducer which is accommodated in a front side portion
5 of the casing. Consequently, when the separable head block is
6 detached from the main casing, at least the ultrasound transducer
7 and its wiring remain on the side of the main casing in an intact
8 state, while other component parts of the rigid tip end section are
9 separated from the main casing in an exposed state partly together
10 with the separable head block. In this regard, joint wall portions of
11 the main casing and the separable head block can be arranged to
12 accommodate, for example, a lens tube of an objective lens system of
13 the optical image pickup assembly unit therebetween in such a way
14 that the lens tube comes out in a free state when the separable head
15 block is detached from the main casing. Considering convenience in
16 actual maintenance and service works, it is desirable to arrange the
17 split lines in such a way as to let the optical image pickup assembly
18 unit or a connector pipe of a biopsy channel comes out separately
19 and independently of other component parts when the separable

1 head block is detached from the main casing..

2 The separable head block is joined with the main casing along
3 longitudinal split lines at its opposite lateral sides and a transverse
4 split line at its front end. In joining the separable block and the main
5 casing together, it is necessary to join them together through joining
6 wall portions which restricts relative movements in both axial and
7 radial directions. After joining the separable head block with the
8 main casing, a foremost one of angle rings of the angle section may
9 be fitted on base end portions of the joined main casing and
10 separable head block to fix the separable block in position relative to
11 the main casing. Otherwise, desirably interlocking or interference
12 surfaces are provided on the joining wall portions to block
13 spontaneous movements of the separable head block relative to the
14 main casing in axial, radial and lateral directions and to retain the
15 main casing and separable block in the joined state more stably. As
16 an example of interlocking surfaces, there may be provided joining
17 wall portions with projections and recesses which are brought into
18 interlocking engagement to restrict relative movements of the main
19 casing and the separable head block in axial and radial directions

1 when the separable head block is joined with the main casing.
2 However, the interlocking engagement of joining wall portions may
3 not be effective for restricting backward movements of the separable
4 head block relative to the main casing. The movements of the
5 separable head block in this direction can be restricted by the
6 foremost ring member of the angle section. Therefore, an annular
7 ring fitting surface substantially of the same diameter as the inside
8 diameter of the foremost ring member of the angle section is formed
9 around base end portions of the main casing and the separable head
10 block when the latter is joined with the former. After fitting the
11 foremost ring member on the annular ring fitting surface, the main
12 casing and the separable head block are separably fixed to each other
13 by the use of a removable fixation means, for example, by threading
14 thereinto a number of set screws through the foremost ring member.
15 More particularly, in such a case, it is necessary to use at least two
16 screws, one screw for stopping the foremost ring member relative to
17 the main casing and another screw for stopping the foremost ring
18 member relative to the separable head block.

19 When the rigid tip end section is assembled by joining the

1 separable head block with the main casing and fitting and fixing the
2 foremost angle ring on base end portions of the joined main casing
3 and the separable head block, it becomes necessary to keep the
4 internal space of the rigid tip end section in a hermetically sealed
5 state. Joined portions between the main casing and the separable
6 head block can be sealed up by the use of seal material, preferably by
7 applying resilient seal material like rubber between and around
8 joined portions. The applying seal material is not necessarily
9 required to have adhesive properties. However, seal material with a
10 weak adhesive power may be applied if desired in consideration of
11 machining accuracy of the main casing and the separable head block.
12 An outer skin layer of the angle section can be utilized in forming a
13 hermetical seal between the foremost angle ring and the ring fitting
14 portions of the main casing and the separable head block. Normally,
15 the outer skin layer of the angle section has resiliency and is
16 stretchable in axial and radial directions. For forming a hermetical
17 seal around the ring fitting portions, the fore end of the outer skin
18 layer is extended forward beyond the position of the foremost angle
19 ring and fixedly anchored in position on joined base end portions of

1 the main casing and separable head block, for example, by the use of
2 line wrapping and an adhesive. In this case, the internal space of the
3 rigid tip end section can be sealed up completely.

4 Interior surfaces of a biopsy channel tube which constitutes a
5 major part of a biopsy channel within the insertion instrument are
6 susceptible to damages because the biopsy channel is often used for
7 introduction of sharp-pointed instruments like a puncture needle.

8 Therefore, arrangement can be made in such a way that the biopsy
9 channel comes out independently and separately of other component
10 parts when the separable head block is detached from the main
11 casing. In this case, a biopsy channel outlet passage on the rigid tip
12 end section is tubular in shape and inclined obliquely upward in the
13 forward direction or toward an outlet opening of the biopsy channel.

14 The tubular biopsy channel outlet passage can be longitudinally split
15 into upper and lower halves. In a case where the biopsy channel
16 outlet passage is inclined over its entire length, the split line is also
17 inclined obliquely. In a case where the biopsy channel outlet passage
18 is arranged in a bent shape, rising obliquely upward from a base end
19 portion which is extended in the axial direction of the insertion

1 instrument, the split line is bent in the same way as the biopsy
2 channel outlet passage and consists of an inclined portion and an
3 axial portion.

4 As the upper and lower halves of the split biopsy channel outlet
5 passage, semi-circular grooves are formed on the meeting side of the
6 separable head block and the main casing, respectively, and a
7 connector pipe of a predetermined length is fitted between upper and
8 lower semi-circular grooves to connect the biopsy channel tube with
9 the biopsy channel outlet passage on the rigid tip end section. In
10 this case, upon detaching the separable head block from the main
11 casing, the connector pipe comes out of the split biopsy channel
12 outlet passage. Therefore, the biopsy channel tube which is
13 connected with the connector pipe can be easily taken out
14 independently and separately of other internal component parts for
15 replacement or for other purposes. The connector pipe which is fitted
16 in the biopsy channel outlet passage retained in a restricted state
17 against movements in axial and rotational directions. As fixation
18 means for this purpose, a set of a stopper projection and a key groove
19 or notch may be provided between the connector pipe and the biopsy

1 channel outlet passage. In this regard, projections or prongs which
2 are provided on the circumferential surface of the connector pipe may
3 be brought into engagement with notches which are provided on the
4 upper and lower semi-circular grooves on the meeting side of the
5 separable head block and the main casing. Since the connector pipe
6 contains a bent portion, the just-mentioned fixation means becomes
7 unnecessary in a case where the bent portion of the connector pipe is
8 immovably fitted in the biopsy channel outlet passage.

9 In some cases, there may arise a necessity for replacing the
10 optical image pickup assembly unit of the endoscopic observation
11 means which is fitted within an endoscopic observation window.
12 Therefore, arrangements may be made in such a way that the optical
13 image pickup assembly unit comes out separately and independently
14 of other internal components when the separable head block is
15 detached from the main casing of the rigid tip end section. The
16 optical image pickup assembly unit has a lens tube for an objective
17 lens system, which should be fixedly mounted on the rigid tip end
18 section. A lens tube fitting hole which is inclined obliquely upward
19 in the forward direction is provided on the rigid tip end section to

1 accommodate the lens tube of the optical image pickup unit
2 assembly. This inclined lens tube fitting hole can also be arranged as
3 a split type, and can also be formed by joining arcuate upper and
4 lower semi-circular grooves which are provided on the separable head
5 block and the main casing. The lens tube is gripped in the lens
6 fitting hole upon joining the upper and lower semi-circular grooves
7 one on the other. The lens tube in the lens tube fitting hole can be
8 locked in axial and rotational directions by the use of fixation means
9 similar to the stopper projection and key groove or notch as described
10 hereinbefore in connection with the connector pipe of the biopsy
11 channel.

12 The above and other objects, features and advantages of the
13 present invention will become apparent from the following particular
14 description of the invention, taken in conjunction with the
15 accompanying drawings which show by way of example some
16 preferred embodiments of the invention. Needless to say, the present
17 invention is not limited to particular forms shown in the drawings.

18 BRIEF DESCRIPTION OF THE DRAWINGS

19 In the accompanying drawings:

1 Fig. 1 is a schematic partly cutaway view of an ultrasound
2 endoscope, showing general layout of the ultrasound endoscope;

3 Fig. 2 is a longitudinal sectional view of a rigid tip end section
4 of an insertion instrument of the ultrasound endoscope according to
5 an embodiment of the present invention;

6 Fig. 3 is a perspective view of the rigid tip end section having a
7 foremost angle ring fitted thereon;

8 Fig. 4 is a fragmentary sectional view showing the manner in
9 which a light guide is fitted in an illumination window on the rigid tip
10 end section;

11 Fig. 5 is a view similar to Fig. 4 but showing another light guide
12 which is fitted in an illumination window on the rigid tip end section
13 in a different manner;

14 Fig. 6 is a schematic perspective view of a main casing of the
15 rigid tip end section and a separable head block which is detached
16 from the main casing, taken from the front side of the rigid tip end
17 section;

18 Fig. 7 is a schematic perspective view of the main casing of the
19 rigid tip end section and a separable head block which is detached

1 from the main casing, taken from the rear side of the rigid tip end
2 section;

3 Fig. 8 is a fragmentary sectional view showing the manner in
4 which an end ring is assembled with the main casing of the rigid tip
5 end section; and

6 Fig. 9 is a perspective view of a rigid tip end section according to
7 a second embodiment of the invention, taken from the front side,
8 showing a main casing and a separable head block which is separated
9 from the main casing.

10 DESCRIPTION OF PREFERRED EMBODIMENTS

11 Hereafter, the present invention is described more particularly
12 by way of its preferred embodiments with reference to the
13 accompanying drawings. Referring first to Fig. 1, there is
14 schematically shown general layout of a typical ultrasound
15 endoscope. In this figure, indicated at 1 is a manipulating head
16 assembly to be gripped by an operator, at 2 an insertion instrument
17 to be introduced into a body cavity of a patient, and at 3 a universal
18 cable. From proximal to fore end, the insertion instrument 2 is
19 composed of an elongated flexible body section 2a, an angle section

1 2b and a rigid tip end section 2c. The flexible body section 2a has a
2 flexible body structure which is bendable in arbitrary directions along
3 a path of insertion toward a patient's body cavity. The rigid tip end
4 section 2c has a rigid structure to support thereon an endoscopic
5 observation means 4 along with an ultrasound examination means 5.
6 The angle section 2b is provided between the flexible body section 2a
7 and the rigid tip end section 2c and manipulated by an angle section
8 operating means 6 on the manipulating head assembly 1 to turn the
9 rigid tip end section into a desired direction. Further, as described in
10 greater detail hereinafter, an exit opening 29 of a biopsy channel is
11 provided on the rigid tip end section 2c. Although not shown in the
12 drawings, other buttons and switches are provided on the
13 manipulating head assembly 1 for controlling the operation of the
14 endoscope.

15 Illustrated in Fig. 2 are the rigid tip end section 2c and those
16 joint portions of the angle section 2b which are connected with the
17 rigid tip end section 2c. Further, shown in Fig. 3 is an outer view of
18 the rigid tip end section 2c which is separated from the angle section.
19 As clear from these figures, the ultrasound examination means 5 is

1 mounted in a front side portion of the rigid tip end section 2c, and
2 the endoscopic observation means 4 is located on the proximal side of
3 the ultrasound examination means 5.

4 In this instance, the ultrasound examination means 5 is
5 provided with an ultrasound transducer 10 having an array of large
6 number of ultrasound transducer elements 11 which are arranged in
7 a convexly curved shape bulging out gradually from its base or rear
8 end toward a most bulged top portion which is located substantially
9 at an axially intermediate point. These ultrasound transducer
10 elements 11 are formed with electrodes on the side of ultrasound
11 signal transmission and reception surfaces as well as on surfaces on
12 the opposite side. Wires 12 are connected separately at least to the
13 respective electrodes on the ultrasound signal transmission and
14 reception surfaces. Regarding the electrodes on the opposite side of
15 the ultrasound transducer elements, wiring connections are made
16 separately to the respective electrodes in some cases but it is the
17 general practice to connect one or a certain number of wires to them
18 as a common electrode. The wires 12 from the respective ultrasound
19 transducer 10 are bundled together and passed through the insertion

1 instrument 2 and the extended into the universal cable 3 via the
2 manipulating head assembly 1.

3 The rigid tip end section 2c is built in a casing of a generally
4 tubular shape, which is provided with a downslope portion in an
5 axially intermediate portion immediately behind the ultrasound
6 transducer 10, and an obliquely rising wall portion 13 rising
7 gradually upward from the rear end of the downslope portion which is
8 located at the lowermost point. The obliquely rising wall portion 13
9 serves as a wall portion for fitting and mounting endoscopic
10 observation means. Namely, an endoscopic observation window 14 is
11 opened at a substantially center position on the obliquely rising wall
12 portion 13, and illumination windows 15 are opened on the right and
13 left sides of the endoscopic observation window 14. It is not
14 necessarily required to provide two illumination windows 15, one at
15 each side of the observation window 14.

16 The sectional view in Fig. 2 is taken longitudinally through the
17 endoscopic observation window 14 which is located centrally of the
18 obliquely rising wall portion 13. For the endoscopic observation
19 window 14, an observation window hole 16 is bored into the proximal

1 end of the rigid tip end section 2c in an obliquely upward direction
2 toward and through the obliquely rising wall portion 13. A lens tube
3 17 is fitted in the observation window opening 16 for an optical
4 objective lens system including an objective lens 18, a cover glass 19
5 in the form of a planoconcave lens which is fitted in the fore end of
6 the lens tube 17, and a prism 20. Further, a solid-state image sensor
7 device 21 is located at the focus of the objective lens 18. The
8 respective component parts which are fitted in the observation
9 window 14 assembled and provided as an image pickup assembly unit
10 22. Signal lines 23 which are led out from the solid-state image
11 sensor device 21 are bundled together and passed through the
12 insertion instrument 2 and extended into the universal cable 3 via
13 the manipulating head assembly 2.

14 As seen in Fig. 4, each illumination window 15 is largely
15 constituted by a light guide 24, which internally contains a large
16 number of fiber optics, and a diffuser lens 25. A light emitting end of
17 the light guide 24 is disposed in the illumination window 15, on the
18 inner side of the diffuser lens 25 which is fitted in a lens mount hole
19 26 which is formed in the casing of the rigid tip end section 2c

1 continuously at the fore end of a light guide fitting hole 27, in which
2 the light guide 24 is fitted. In this instance, the light guide fitting
3 hole 27 is formed in a bent shape having a sloped portion extending
4 gradually downward over a certain length from its fore end in
5 communication with the lens fitting hole 26 and then connected to a
6 rear rectilinear portion which is extended in the axial direction of the
7 rigid tip end section 2c. The light guide 24 is flexible in bending
8 directions of the insertion instrument, and its fore end is stopped in a
9 metal piece 24a which is in turn fixed in position by a set screw 24s.
10 Further, in a case where the light guide 24 is fitted in a rigid pipe 24b
11 at a bent portion of the light guide fitting hole 27, the light guide 24
12 is securely retained in position by the rigid pipe 24b.

13 Further, an outlet passage 29 of the biopsy channel is opened
14 in the obliquely rising wall portion 13, and a forwardly rising guide
15 surface 28 is on the downslope portion on the rear side of the
16 ultrasound transducer 10. Through the outlet passage 29, various
17 biopsy and surgical instruments can be projected into a body cavity of
18 a patient, including forceps or other biopsy or surgical instruments to
19 be operated under observation by the endoscopic observation means

1 4 and those instruments like a puncture instrument with a puncture
2 needle to be operated under observation by the ultrasound
3 examination means 5. A required biopsy or surgical instrument is
4 introduced into the biopsy channel through an inlet passage 7 which
5 is provided in the casing of the manipulating head assembly 1.
6 Accordingly, a biopsy channel 30 is extended from the inlet passage 7
7 on the manipulating head assembly 1 to the outlet passage 29 on the
8 rigid tip end section 2c of the insertion instrument of the endoscope.

9 Between the inlet passage 29 and a point in the proximity of or
10 immediately on the proximal side of the rigid tip end section 2c, the
11 biopsy channel 30 is constituted by a flexible tube 31 which is
12 extended axially through the insertion instrument 2. A biopsy
13 channel outlet passage way 32 is formed within the casing of the rigid
14 tip end section 2c. In order to connect the biopsy channel tube 31 to
15 the outlet passage way 32, a connector pipe 33 is provided between
16 these parts. In this instance, the outlet passage way 32 which leads
17 to the biopsy channel outlet 29 is inclined upward toward the biopsy
18 channel outlet 29. Therefore, the connector pipe 33 is bent in an
19 axially intermediate portion to switch the direction of the biopsy

1 channel in an obliquely upward direction toward the outlet opening
2 29 at the fore end of the biopsy channel tube 31 which is extended in
3 the axial direction of the insertion instrument 2.

4 In this particular embodiment, as shown in Figs. 6 and 7, the
5 rigid tip end section 2c is housed in a separable casing which is
6 composed of a main casing 40 and a separable head block 50. The
7 main casing 40 includes a front compartment 41 for accommodating
8 the ultrasound transducer 10, a downslope wall portion 42 which is
9 provided on a rear section of the front compartment 41 and inclined
10 downward toward the rear end of the rigid tip end section 2c, lens
11 fitting wall portions rising obliquely upward from right and left side
12 portions of the downslope wall portion 42 and provided with lens
13 fitting portions 43 with apertures or through holes for fitting
14 illumination light diffuser lenses 25, and a tubular neck portion 44
15 which is formed continuously on the rear side of the lens fitting
16 portions 43 and configured with three stepped circumferential walls.
17 Provided centrally of the tubular neck portion 44 is an arcuate or
18 semi-circular groove 32L which forms a lower half of the biopsy
19 channel outlet passage 32 leading to the outlet opening 29 of the

1 biopsy channel. Further, provided on the right and left sides of the
2 semi-circular groove 32L are semi-circular grooves 27L which form
3 lower halves of the light guide fitting holes 27 leading to the
4 apertures in the diffuser lens fitting portions 43.

5 The neck portion 44 is provided with three stepped
6 circumferential wall portions, including a large diameter portion 44a
7 which is located on the front side of the neck portion 44, and an
8 intermediate diameter portion 44b which is sunken stepwise from the
9 large diameter portion 44a in an extent corresponding substantially
10 to the thickness of a skin layer of the angle section 2b which will be
11 described more particularly hereinlater. Further, formed
12 continuously on the rear side of the intermediate diameter portion
13 44b is a small diameter portion 44c. The small diameter portion 44c
14 is sunken stepwise from the intermediate diameter portion 44b in an
15 extent corresponding substantially to the thickness of an angle ring
16 in the angle section 2b. Lower bottom portions of the internal space
17 of the neck portion 44 are utilized as a passage for the wires 12 from
18 the ultrasound transducer 10.

19 On the other hand, the separable head block 50 is arranged to

1 close the open top of the neck portion 44 in such a way that the rear
2 end of the rigid tip end section 2b generally presents a cylindrical
3 shape. Therefore, the separable head block 50 is configured with
4 three stepped circumferential walls, i.e., a large diameter portion 50a,
5 an intermediate diameter portion 50b and a small diameter portion
6 50c conforming in diameter with the large diameter portion 44a,
7 intermediate diameter portion 44b and small diameter portion 44c of
8 the tubular neck portion 44, respectively. Further, formed on the
9 inner side of the separable head block 50 is a semi-circular groove
10 32U which forms the upper half of the biopsy channel outlet passage
11 32 leading to the outlet opening 31 of the biopsy channel 30.
12 Furthermore, formed on the right and left sides of the semi-circular
13 groove 32U are semi-circular grooves 27U which form upper halves of
14 the light guide fitting holes 27.

15 As described above, the light guide fitting hole 27 and the
16 biopsy channel outlet passage 32 are constituted by the semi-circular
17 grooves 27L, 27U, 32L and 32U which are formed opposingly on the
18 neck portion 44 and the separable head block 50. These semi-
19 circular grooves 27L, 27U, 32L and 32U are provided joining surfaces

1 on the opposing side wall portions to be engaged tightly with each
2 other. Further, the fore end face of the separable head block 50 is
3 abutted against circumferential wall portions of the lens fitting
4 portions 43 on the side of the main casing 40. More particularly,
5 joining wall sections 43P are provided on the inner side of the lens
6 fitting portions 43 of the main casing 40 for engagement with
7 opposing joining wall sections 51P which are provided on right and
8 left fore end portions of the large diameter portion 50a of the
9 separable head block 50. Formed at one side of these joining wall
10 sections 43P and 51P on the main casing 40 and the separable head
11 block 50 are interlocking portions 43S and 51S each with a tapered
12 surface (or an arcuate surface) which is inclined obliquely outward in
13 the downward direction. As these interlocking portions 43S and 51S
14 are engaged with each other, the separable head block 50 is
15 restricted of movements not only in lateral rightward and leftward
16 directions but also in a direction away from the main casing 40 of the
17 rigid tip end section.

18 Accordingly, at the time of fitting the separable head block 50
19 in the main casing 40 of the rigid tip end section, the interlocking

1 portions 51S of the separable head block 50 are slid into the inner
2 side of the interlocking portions 43S on the side of the main casing
3 40 from the rear side of the latter until the joining wall sections 43P
4 and 51P come into abutting engagement with each other.

5 Whereupon, the rigid tip end portion 2c is assembled as shown in Fig.

6 3. At the time of joining the separable head block 50 with the main
7 casing 40 of the rigid tip end section 2c, it is desirable to apply either
8 weakly adhesive seal material or non-adhesive seal material around
9 joined portions to keep the internal space of the rigid tip end section
10 in a hermetically sealed state.

11 The rigid tip end section 2c is required to accommodate, in
12 addition to the ultrasound transducer 10 and the wires 12 from the
13 respective ultrasound transducer elements 11, the image pickup
14 assembly unit 22 in the endoscopic observation window 14, the light
15 guides 24 to the illumination windows 15, and the connector pipe 33
16 which connects the biopsy channel tube 31 to the biopsy channel
17 outlet passage in the casing 40. Among the various component parts
18 just mentioned, the ultrasound transducer 10 including the wires 12
19 and the image pickup assembly unit 22 are built in the main casing

1 40 and the separable head block 50 beforehand, respectively.

2 On the other hand, the light guides 24 and connector pipe 33
3 are fitted into respective positions when the separable head block 50
4 is assembled with the main casing 40. More particularly, the light
5 guides 24 are placed in the semi-circular grooves 27L on the side of
6 the main casing 40, and then the separable head block 50 is joined
7 with the main casing 40. Whereupon the semi-circular grooves 27U
8 on the separable head block 50 are closed on the light guides 24 in
9 the lower semi-circular grooves 27L of the light guide fitting holes 27.
10 The light guides 24 are fixed in position by set screws 24S. Each light
11 guide 24 can be fixedly retained in position because the rigid pipe
12 24b is set in the bent portion of the light guide fitting hole 27.

13 The connector pipe 33 also contains a bent portion so that it
14 can be fixed in both radial and axial directions if it is extended
15 beyond a bent portion of the biopsy channel outlet passage in a
16 manner similar to the light guide 24. In the particular embodiment
17 shown, as shown in Fig. 2, a stopper notch 46 is provided within the
18 length of the lower or upper semi-circular groove 32L (or 32U) which
19 is formed on the main casing 40 (or on the separable head block 50)

1 as a lower or upper part of the biopsy channel outlet passage 32. A
2 stopper protuberance 52 is provided on the side of the connector pipe
3 33 for fitting engagement with the stopper notch 46 in the semi-
4 circular groove 32L or 32U. Accordingly, the stopper protuberance 52
5 is engaged with the stopper notch 46 at the time of placing the
6 connector pipe 33 in the semi-circular groove 32L, which is the lower
7 part of the biopsy channel outlet passage 32. Then the separable
8 head block 50 is joined with the main casing 40. As soon as the
9 separable head block 50 is set in position on the main casing 40, the
10 connector pipe 33 is fixed in position and its spontaneous movement
11 is blocked in both radial and axial directions.

12 Even if various component parts have been assembled into the
13 rigid tip end section 2c in the manner as described above, the main
14 casing 40 and the separable head block 50 are not yet strongly fixed
15 to each other although seal material is applied at joined portions. As
16 shown in Figs. 2 and 3, the main casing 40 and the separable head
17 block 50 are securely fixed to each other by means of a foremost ring
18 member 61 in a series of angle rings 60 which constitute the angle
19 section 2b of the insertion instrument 2.

1 After joining the separable head block 50 with the neck portion
2 44 of the main casing 40, the above-mentioned foremost ring member
3 61 is fitted on the small diameter portions 44c and 50c of the main
4 casing 40 and the separable head block 50. Then, as shown also in
5 Fig. 8, the foremost ring member 61 is fixed to both of the main
6 casing 40 and separable head block 50 by the use of at least one flat
7 head screw 62. For this purpose, a number of tapered holes 63 are
8 formed into the outer peripheral surface of the foremost ring 61 at
9 suitable angular intervals and at suitable positions relative to screw
10 holes 64 which are tapped into the small diameter portion 44c of the
11 neck portion 44 of the main casing 40 and the separable head block
12 50. By tightening the flat head screws 62 into the screw holes 64
13 through the tapered holes 63 in the foremost ring member 61, the
14 main casing 40 and the separable head block 50 are completely
15 restricted of spontaneous movements not only in forward and
16 backward directions but also in a separating direction away from each
17 other. In addition, the main casing 40 and the separable head block
18 50 are virtually integrally joined together in such a way as to prevent
19 relative positional deviations not only in radial and axial directions

1 but also in a separating direction.

2 In this connection, it is not necessarily required for the fitting
3 portion of the foremost ring member 61 to have a function as a seal.
4 However, arrangements may be made to bond the foremost ring
5 member 61 in position with a moderate adhesive power, permitting to
6 detach the ring member 61 afterwards relatively easily whenever the
7 necessity arises. A flexible outer skin layer 65, with flexibility in
8 stretching and bending directions, is fitted around the angle section
9 2b in such a manner as to cover the entire angle rings 60 including
10 the foremost ring member 61. The outer skin layer 65 is extended
11 forward of the angle section 2b beyond the fore end of the foremost
12 ring member 61 and onto the intermediate diameter portions 44b and
13 50b of the neck portion 44 and the separable head block 50. A fore
14 end portion of the outer skin layer 65 is fixedly anchored on the
15 intermediate diameter portions 41b and 50b by applying an adhesive
16 around line wrapping 66.

17 The above-described construction of the rigid tip end section
18 makes it possible to inspect, repair and replace internal component
19 parts of the insertion instrument 2 in an extremely facilitated

1 manner. For maintenance and service of internal component parts,
2 disassembling of the rigid tip end section 2c is started by removing
3 the adhesive and line wrapping 66 from around the outer skin layer
4 65, and then the outer skin layer 65 is tucked backwards toward the
5 angle section 2b with fingers until the foremost ring member 61 is
6 completely exposed. In this state, the flat head screws to permit
7 separation of the separable head block 50 from the main casing 40 of
8 the rigid tip end section 2c. Up to this point, there is no difference in
9 particular from the prior art in terms of disassembling procedure.

10 Upon removing the flat head screws 62, the rigid tip end section
11 2c can be split into the main casing 40 and the separable head block
12 50. Besides, upon splitting the rigid tip end section 2c, the connector
13 pipe 33 in the biopsy channel outlet passage 32 can be detached
14 independently. Therefore, if necessary, the flexible biopsy channel
15 tube 31 can be easily removed from the connector pipe 31 and
16 replaced by a new one. In this connection, taking into consideration
17 the fact that inner surfaces of the biopsy channel tube 31 which is
18 repeatedly used for introduction of a puncture instrument are
19 susceptible to damages and buckling, it is important and

1 advantageous to make the biopsy channel tube 31 easily accessible
2 for replacements. This maintenance and service work can be carried
3 out without removing, relocating or touching other component parts,
4 especially the ultrasound transducer 10 which is built in the main
5 casing 40 along with the wires 12.

6 Similarly, the light guides 24 can be taken out independently
7 of other component parts. Breakage could occur to the light guide 24
8 which is comprised of fiber optics. However, in case of breakage, it
9 can be easily replaced. Furthermore, the optical image pickup
10 assembly unit 22 is fixedly assembled with the separable head block
11 50. Therefore, upon detaching the separable head block 50 from the
12 main casing 40, the solid-state image sensor device 21 and signal
13 lines 23 are exposed on the inner side of the separable head block 50
14 and are easily accessible for an inspection or repair work or for other
15 purposes.

16 Upon completion of an inspection, repair or replacement work
17 on the opened rigid tip end section 2c, the respective internal
18 components are relocated to the respective positions before rejoining
19 the separable head block 50 with the main casing 40. The separable

1 head block 50 and the main casing 40 are securely fixed to each
2 other by threading the flat head screws 62 through the foremost ring
3 member 61. Finally, the fore end of the outer skin layer 65 is
4 anchored by applying line wrapping and adhesive therearound to put
5 the insertion instrument 2 back into the initial closed and sealed
6 state.

7 In the above-described embodiment, the separate block 50 is
8 arranged to be separable from the main casing 40 along a split line
9 which is located at the position of or across the biopsy channel outlet
10 passage 32 especially for the purpose of facilitating replacements of
11 the biopsy channel tube 31 among various internally fitted
12 component parts of the insertion instrument. However, in a case
13 where maintenance and service of the optical image pickup assembly
14 unit is required at a higher frequency, it will be more convenient to
15 arrange the main casing and the separable head block in the manner
16 as in a modification shown in Fig. 9. In this case, a split line of a
17 separable head block 71 so determined as to leave the biopsy channel
18 outlet passage on the side of a main casing 70 of the rigid tip end
19 section 2c, receiving a lens tube 72 of an optical image pickup

1 assembly unit in an optical lens fitting hole 73 which is split into an
2 arcuate groove 73L on the side of the main casing 70 and an arcuate
3 groove 73U on the side of the separable head block 71. Both of these
4 arcuate grooves 73L and 73U are semi-circular in cross-section and
5 arranged to hold the lens tube 72 fixedly therebetween when joined
6 with each other.

7 Similarly to the main casing 40 and separable head block 50 in
8 the foregoing first embodiment, large diameter portions 70a and 71a,
9 intermediate diameter portions 70b and 71b and small diameter
10 portions 70c and 71c are provided on a neck portion of the main
11 casing 70 and the separable head block 71. A foremost ring member
12 of the angle section is fitted on the small diameter portions 70c and
13 71c and the joined main casing 70 and separable head block 71 are
14 securely fixed to each other by flat head screws in the same manner
15 as in the above-described first embodiment. Further, a fore end of an
16 outer skin layer of the angle section 2b is extended onto the
17 intermediate diameter portions 70b and 71b and fixedly anchored
18 thereon in the same manner as in the first embodiment.

19 Assembled with the lens tube 72 are solid-state image sensor

1 device 74 and other parts which constitute an optical image pickup
2 assembly unit 75. Since the lens tube 72 is assembled with the solid-
3 state image sensor device 74, it has to be fixed in the rotational
4 direction. Therefore, a pair of stopper projections 72a are provided on
5 the outer periphery of the lens tube 72, for engagement with notches
6 76 which are provided in corresponding positions in the arcuate
7 grooves 73L and 73U, which are provided on the main casing 70 and
8 the separable head block 71 to form the lens tube fitting hole 73 (a
9 notch in the arcuate groove 73U is not seen in the drawing). As a
10 consequence, in an assembled state, there is no possibility of
11 spontaneous positional deviations occurring to the separable head
12 block 71 and the image pickup assembly unit 75. At the time of
13 replacing the image pickup assembly unit 75, the separable head
14 block 71 is detached from the main casing in the same manner as in
15 the foregoing first embodiment. Whereupon, the image pickup
16 assembly unit 75 can be detached from the rigid tip end section 2c
17 separately and independently of the main casing 70 and the
18 separable head block 71. Accordingly, even in this case, there is no
19 possibility of damaging the ultrasound transducer 10 and its wiring

1 10 in carrying out maintenance and service on the image pickup
2 assembly unit 75.

3 As clear from the foregoing description, the rigid tip end section
4 of an endoscopic insertion instrument is constituted by a main casing
5 and a separable head block which is separably joined with the main
6 casing. The provision of the rigid tip end section which can be split
7 into the main casing and separable head block make it extremely
8 easy to carry out maintenance and service, including inspection,
9 repair and replacements, of internally fitted component parts of the
10 rigid tip end section of the insertion instrument.